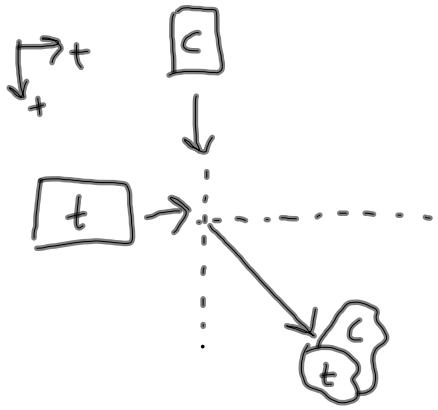
Car with mass = 2300 kg is traveling South at 42 m/s. A truck with mass = 4600 kg is traveling east at 21 m/s. If they collide and stick together, what is their final velocity? (Give magnitude, angle, and direction)



x-direction:

$$\bar{P}_{fx} = \bar{P}_{ix} = \bar{P}_{cix} + \bar{P}_{tix}$$

$$= m_t \bar{V}_{tix}$$

$$= 96600 \text{ kg} \cdot \text{m/s}$$

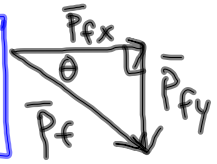
y-direction:

$$\bar{P}_{fy} = \bar{P}_{iy} = \bar{P}_{ciy} + \bar{P}_{tiy}$$

$$= m_c \bar{V}_{ciy}$$

$$= 96600 \text{ kg} \cdot \text{m/s}$$

$\bar{V}_f = 19.8$ m/s @ 45° S of E



$\theta = 45°$ S of E

$P_f^2 = P_{fx}^2 + P_{fy}^2$

$\bar{P}_f = (m_c + m_t)\bar{V}_f$

Steps:

1. Find $\overline{P}_{fx}$.
2. Find $\overline{P}_{fy}$.
3. Make a p_f triangle.
4. To find v_f, divide p_f by combined mass.

   (Angle and direction of $\overline{P}_f$ is the same as $\overline{V}_f$.)

Green ball (m_G = 4kg) moving to the right at 20 m/s. Stationary red ball (m_R = 10kg) is hit with green ball, and the collide elastically. If the red ball has a final velocity of 12 m/s to the right, what is the green ball's final velocity?

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1D Elastic

$$\bar{P}_{Gi} + \bar{P}_{Ri} = \bar{P}_{Gf} + \bar{P}_{Rf}$$

$$m_G\bar{v}_{Gi} + m_R\cancel{\bar{v}_{Ri}} = m_G\bar{v}_{Gf} + m_R\bar{v}_{Rf}$$

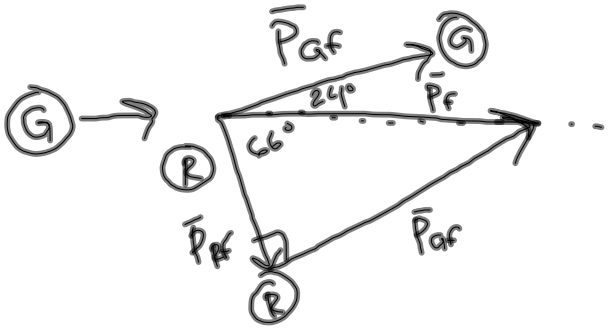
$$v_{Gf} = \frac{1}{m_G}\left[m_G\bar{v}_{Gi} - m_R\bar{v}_{Ri}\right]$$

$$= \frac{1}{(4kg)}\left[(4kg)(20\,m/s) - (10kg)(12\,m/s)\right]$$

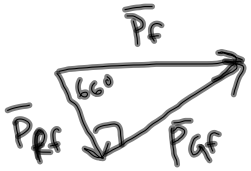
$$= -10\ m/s \quad (10\ m/s\ left)$$

Green ball has $m_G = 10\ kg$ and is moving at 14 m/s. Red ball is stationary, and they collide elastically. The green ball goes off at an angle of 24° N of E, and the red ball goes at an angle of 66° S of E. Find the final velocity of the green and red. ($m_R = 20\ kg$)

2D elastic



$$\bar{P}_f = \bar{P}_i = \bar{P}_{Gi}$$
$$= m_G \bar{V}_{Gi}$$
$$= 140\ kg \cdot m/s$$



$$\cos(66°) = \frac{P_{Rf}}{P_f} \qquad \sin(66°) = \frac{P_{Gf}}{P_f}$$

$$P_{Rf} = 56.9\ kg \cdot m/s \qquad P_{Gf} = 127.9\ kg \cdot m/s$$

$$V_{Rf} = \frac{P_{Rf}}{m_R} \qquad V_{Gf} = \frac{P_{Gf}}{m_G}$$

$$= 2.85\ m/s \qquad = 12.7\ m/s$$

A force of 25 N is applied for 5 s. If the object has a mass of 50 kg and starts with a velocity of 2 m/s, what is its final velocity?

Impulse-Momentum

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$$\bar{J} = \Delta\bar{p}$$

$$\bar{F}\Delta t = m\Delta\bar{v}$$

$$= m(\bar{v}_f - v_i)$$

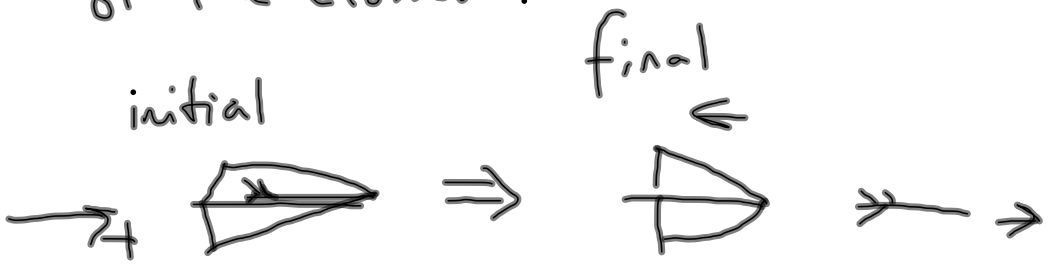
$$\bar{v}_f - \bar{v}_i = \frac{\bar{F}\Delta t}{m}$$

$$v_f = \frac{\bar{F}\Delta t}{m} + \bar{v}_i$$

$$= \frac{(25\ N)(5\ s)}{50\ kg} + 2\ m/s$$

$$= 4.5\ m/s$$

An arrow (mass = 450 g) is loaded on a crossbow (mass = 12 kg). The arrow is fired with a velocity of 120 m/s from rest. What is the (recoil) velocity of the crossbow?



b = bow
a = arrow

$$(m_b + m_a)\cancel{v_i} = m_b \bar{v}_{fb} + m_a \bar{v}_{fa}$$

$$v_{fb} = \frac{-m_a v_{fa}}{m_b}$$

$$= \frac{-(.45\ \text{kg})(120\ \text{m/s})}{12\ \text{kg}}$$

$$= -4.5\ \text{m/s}$$